A Feasibility Study to Lower Steam Generator Low Water Level Trip Setpoint to Reduce Unnecessary Scram Frequency for KORI 3,4 Plant

M.S.Jung, C.S.Lee, G.C.Lee, E.K.Kim
Korea Power Engineering Company
150 Deokjin-dong, Yuseong-gu, Daejeon, Korea, 305-353
Tel : 82-42-868-4167, Fax : 82-42-861-1485, E-Mail : msjung@kopec.co.kr

1. Introduction

The steam generator low water level trip setpoint of KORI NPP units 3&4(KNU 3&4), three-loop Westing-house pressurized water reactor, is higher than that of OPR1000. In addition, steam generator downcomer water level in KNU 3&4 could fluctuate easily during a transient because of smaller downcomer water inventory, compared to the total water inventory in the steam generator. Due to these reasons, there is a higher possibility of unnecessary reactor trips caused by the steam generator low-low water level in KNU 3&4. Its operating history shows that most of reactor trips were caused by steam generator low-low level reactor trip signal. Such reactor trips, especially unnecessary ones, result in time and economic losses. In this paper, a feasibility study was performed to reduce unnecessary reactor trip by changing steam generator low-low water level reactor trip setpoint(SGLLRTS) for KNU 3&4.

2. Methods and Results

In the final safety analysis report for KNU 3&4, there are five accidents related to the SGLLRTS. Among them, loss of normal feedwater(LONF) is selected in this sensitivity study as a limiting case. Details on the selection of transients are described in Reference 1.

2.1 Procedure

The KNU 3&4 is tripped by the SGLLRTS at 17% steam generator narrow-range water level span under the transient condition. This study is performed to evaluate how much the SGLLRTS can be lowered to satisfy the pressurizer overfill criteria during the entire transient period of the LONF event. Transients were analyzed using the RETRAN-3D code to demonstrate that steam generator low-low water level reactor trip setpoint could be lowered to improve plant operations and eliminate unnecessary reactor trip.

Table 1. Initial Conditions

Parameter	Value
Core Power (MWt)	2,912.5
Core inlet temperature (℃)	291.9
Core average temperature (℃)	310.0
Pressurizer pressure (kg/cm^{2}A)	160.65
RCS flow rate (10^6 kg/hr)	49.49
SG pressure (kg/cm^{2}A)	69.6
SG feedwater temperature (℃)	226.7
Doppler Coefficient, pcm/℃	Least negative
MTC, pcm/℃	0

2.2 Initial Condition

The RETRAN-3D model for this analysis was initialized same as KNU 3&4 FSAR parameters of primary and secondary side[2]. Initial conditions are listed in Table 1. In this study, power uprated conditions are used as initial values[3]. Figure 1 shows the steam generator nodalization of KNU 3&4. The Steam generator is modeled by a seven volume, which is selected by considering the accuracy of SG liquid level prediction and the computing cost[4,5]. Figure 2 presents the comparison of the pressurizer pressure transients between RETRAN-3D model and KNU 3&4 FSAR. As shown in this figure, overall trends show almost same response except reactor trip time.

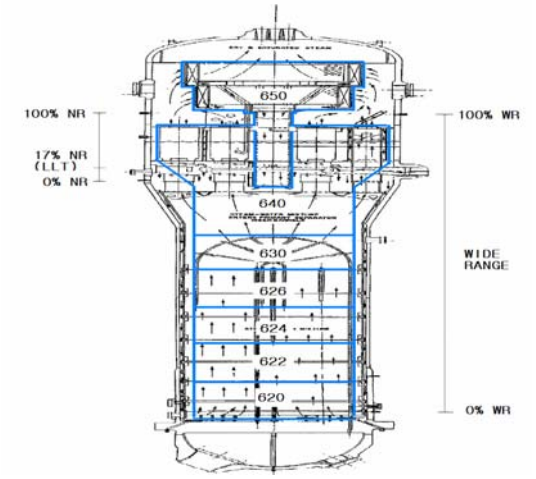

Figure 1. RETRAN-3D Nodalization for KNU 3&4 Steam Generator

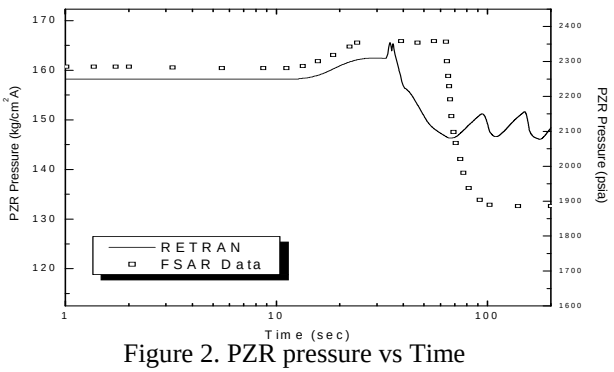

Figure 2. PZR pressure vs Time

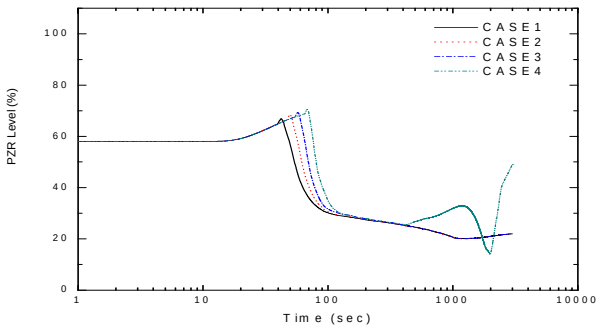

Figure 3. Comparison of PZR level for four cases

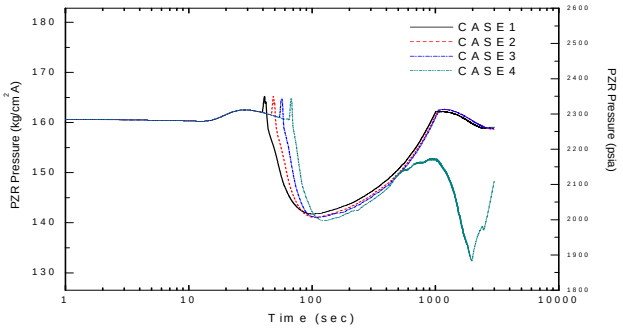

Figure 4. Comparison of PZR pressure for four cases

Acceptance criterion for LONF event is that the pressurizer should not be overfilled throughout the transient.

2.3 Analysis Results of LONF

SG inventory corresponding to low-low level reactor trip setpoint is generated by GENF computer code and used as an input to RETRAN-3D. Four cases were selected to evaluate the possibility of lowering steam generator low-low level reactor trip setpoints. Table 2 depicts the summary of analysis conditions and results for four cases. Figure 3 and 4 show comparison of PZR pressure and PZR level variation for the four cases. When the SG water level reaches the SGLLRTS, it causes the turbine trip and may lead to a reactor trip. After turbine and reactor trip, reactor coolant system pressure and temperature quickly increase and the steam generator water level decreases due to the level shrinkage and the continued release of steam through main steam safety valves. One minute after the SG low-low water level trip signal, at least one auxiliary feedwater pump is automatically started to reduce the rate of water level decrease. Figures 3 and 4 show no impact to the integrity of the RCS for all of cases because a reactor trip and auxiliary feedwater actuation on SG low-low water level provide sufficiently the necessary protection against a loss of normal feedwater. This demonstrates that lowering steam generator low-low reactor trip setpoint from 17% narrow range span (NRS) to 30% wide range span (WRS) will not cause adverse effects such water relief through the pressurizer safety valves.

Table 2. Key Parameter Results

Case	Condition	Peak PZR level
1	81% WRS[17% NRS] SGLLRTS (83050lbm)	66.95%
2	77.1%[0% NRS] SGLLRTS (72927lbm)	68.57%
3	68% WRS SGLLRTS (63381lbm)	69.28%
4	30% WRS SGLLRTS (45425lbm)	70.48%

3. Conclusions

This paper evaluates how much the SG low-low level trip setpoint can be lowered to satisfy the pressurizer overfill criteria during the entire transient period of the loss of normal feedwater flow event. Based on the results of sensitivity study for relaxing steam generator low-low water level trip setpoint, the SGLLRTS can be lowered at least from 17% narrow-range water level span to 30% wide-range water level span for full power condition. It is indicated that SGLLRTS can be changed with enough margin for KNU 3&4. However the LONF event is investigated only in this study, and hence the results of the study show only the lowered steam generator low-low water level tap effect with respect to PZR overfills. Therefore, a further study needs to evaluate the effects on reactor coolant system from various viewpoints for relaxing steam generator low-low water level reactor trip setpoint.

REFERENCES

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